From The Editor | July 31, 2014

How To Avoid Sewer Stench And Corrosion

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You might think sewer stench should be expected, considering what's flowing through the pipes. But that's not the expectation of the public — nor should it be, since there are tools available to greatly mitigate offensive odors. The sewer stench scientists tell us that the odors we smell from sewers does not come in with the wastes, but it is generated in the sewer itself. The same conditions that cause the odors also cause corrosion, so an understanding of those conditions, as well as techniques for abatement, is essential for proper collection system design, operation, and maintenance.

An overview of wastewater odor generation and sewer corrosion was presented by Jim Joyce, PE, of V&A Consulting Engineers during a recent webinar conducted by the Water Environment Federation (WEF). Joyce notes that while some of the odors in sewers come from wastes discharged into the sewer (e.g., fecal, grease, and industrial discharges) the strongest and most noticeable odors — and those responsible for the corrosion of sewers, resulting in degradation and/or collapse — arise from inorganic compounds produced in the sewer by the natural biology.

The Problem: Hydrogen Sulfide (H2S)

H2S is nasty stuff. The colorless gas is not only unpleasant, giving off that all-too-familiar "rotten egg" smell, it is also poisonous, flammable (even explosive in high concentrations), and ultimately corrosive to metal and concrete. But H2S generation in sewers depends upon a fairly complicated biological, chemical, and physical process that is worthy of its own production pathway.

The process starts when natural microbiology that lives below the waterline in a sewer converts sulfate (which occurs naturally and harmlessly in almost all drinking water supplies), into ionic sulfide, which is then chemically changed into dissolved H2S. The dissolved H2S is then released from the water by turbulence and splashing to exist as H2S gas, which causes the stench. Finally, H2S gas is converted to sulfuric acid by a second type of bacteria (*Thiobacillus*) that live above the water line; the sulfuric acid drips back down into the wastewater where it is neutralized back into sulfate, and the process begins all over again. This is what Joyce terms the "Sewer Sulfide Cycle," which can be used to identify ways to solve many of the problems it causes.

Breaking The Cycle

Naturally occurring sulfate-reducing bacteria live in a "slime layer" that covers all surfaces below the waterline in a sewer, including the bottom half of the pipes themselves, as well as any settled debris or other materials. Rocks, sand, and other debris that finds its way into the sewer settles to the bottom and greatly increases the surface area of the slime layer per foot of length. As a result, sulfate conversion and dissolved sulfide production is also greatly increased. However, there are ways to interrupt the "sulfide cycle," reduce dissolved sulfide concentration, avoid H2S gas release, and prevent corrosion as discussed below.

- Reduce slime layers by removing debris
- Control dissolved sulfide through chemical addition
- Reduce H2S gas release through turbulence reduction
- Protect sensitive surfaces from the effect of acid generation

The first solution is pretty easy to figure out: Clean sewers of settled debris to reduce the area of slime layer and minimize dissolved sulfide generation. Next, consider chemical addition to control the dissolved sulfide that is generated. Iron chemicals, nitrate, hydrogen peroxide, and caustic in the form of sodium hydroxide and magnesium hydroxide are all common choices that can effectively control dissolved sulfide concentrations, according to Joyce. He notes that the advantages of chemical-addition facilities are quick installation and low capital cost, but also cautions that chemicals can have high long-term costs, are most often hazardous to handle and dangerous to transport, and can be maintenance-intensive.

Iron, nitrate, and peroxide react stochiometrically with dissolved sulfide, meaning that higher levels of dissolved sulfide require higher doses of chemical to prevent the release of H2S gas. Magnesium hydroxide is not stoichiometric; it can be effective at a single addition rate regardless of the dissolved sulfide concentration, but it can have a higher cost than the other chemical alternatives at lower sulfide concentrations.

Ironically, improvements in environmental regulations have caused an increase in the wastewater-related odor and corrosion issues commonly experienced today. The Clean Water Act (Title III) reduced the amount of heavy metals in collection systems by requiring industrial pretreatment. Those metals, including chromium, copper, mercury, cadmium, nickel, and many others, were passing through treatment plants, bio-accumulating in receiving waters and causing damage to flora and fauna. It was discovered that these dangerous metals had been inhibiting the growth of sulfate-reducing bacteria in the slime layer, making them produce less dissolved sulfide. Once these heavy metals were removed, the slime layer became very active, resulting in a general increase in dissolved sulfide in the sewers in the U.S. Furthermore, decreased infiltration and inflow (I&I) and the separation of combined sewers, as well as water conservation practices, have increased biochemical oxygen demand (BOD), which is the main food source for the slime layer. The combination of these factors has increased dissolved sulfide production in sewers and caused utilities to spend much more on sulfide controls, chemicals, odor scrubbers, and repair of corrosion damage.

Worst-Case Scenario

With high dissolved sulfide comes excessive odor and corrosion problems, and we have seen the conditions under which sulfide generation thrives. The conditions that lead to excessively high sulfide production are listed below, and although some are more controllable than others, Joyce warns that having two or more of these conditions present in your sewer system could lead to significant problems and costly solutions.

- Warm annual sewage temperatures (Average > 70 degrees F)
- Long force mains and/or flat sewers with debris
- High BOD wastewater (> 250 mg/L)
- High sulfate wastewater concentrations (> 40 mg/L)

Protect Your Pipes

So it happens that you are prone to the effects of the Sewer Sulfide Cycle and thus vulnerable to corrosion. What are some methods you can use to protect your pipes? Joyce offers the following tips:

Minimize turbulent stripping of hydrogen sulfide gas — The splashing and turbulence from falling water and outfalls in the collection system causes H2S gas to be stripped out of the water and into the air, where it can cause odors and be further oxidized to sulfuric acid. Reducing turbulence at drop manholes, Parshall flumes, and other hydraulic outfalls will reduce the H2S gas concentration, resulting in less odor and corrosion.

Use inert pipe materials — Fiberglass reinforced plastic (FRP), PVC, HDPE, and clay are examples of pipe materials that are inert (chemically inactive) when exposed to sulfuric acid.

Use only 316L stainless steel or plastics for attachments — According to Joyce, 316 stainless steel and 316L (the low-carbon version of 316 stainless steel) are the only metals shown to stand up to the effects of sulfuric acid in sewers. No other metals should be used unprotected in a sewer environment.

Use liners to protect concrete surfaces — Joyce recommends plastic liners to protect concrete surfaces, as opposed to applied coatings, due to the former's longer demonstrated lifespan. Options include:

1. *Mechanically attached plastic liners*, which require punctures, bolts, and welding for application. They are acceptable for structures in low-hydraulic-energy situations, but not good for pipelines.
2. *"T-lock" cast-in-place liners*, where the flexible PVC is "locked" via anchoring T's into the interior of concrete sewer pipes during manufacture or rehabilitation. The process and product is "very secure," notes Joyce, with a long track record (over 50 years) of successful service in sewers.
3. *Applied liners*, in which PVC sheets are essentially "glued" to the concrete surface with either a sprayed urethane bonding agent or an epoxy mastic. "It's basically wallpaper for sewers," describes Joyce, adding that applied liners are widely deployed and "can be very successful when used appropriately."

Use coatings only where easily visible to catch repairs — Joyce notes that "coatings have a role ... in applications where they can be viewed easily to catch repairs when damage is done, when pinholes start to erupt, and when coatings start to fail." Such applications would include manholes, junction boxes, and channels at treatment plants where re-coating can be accomplished fairly easily.

Lingering Problem

While Joyce remains optimistic that the U.S. wastewater industry can effectively deal with its current sulfide odor and corrosion problems, he estimates that a staggering 90 percent of all the H2S gas released in a collection system never makes it out. It is instead converted to sulfuric acid, which in turn causes potentially catastrophic corrosion. Despite the natural and circumstantial obstacles conspiring against sewer system managers, it is a problem in need of a fix. That smell is more than just a nuisance — it's a warning.